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Early unplanned reoperations in supratentorial brain tumors

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ABSTRACT

Background: Surgical treatment of brain tumors were proved to be at highest risk of unplanned reoperation. Therefore, we decided to find possible predictors of complications leading to early unplanned reoperations among patients with supratentorial brain tumors.

Methods: We retrospectively analysed 328 patients who underwent craniotomy due to supratentorial brain tumor. Early reoperation was defined as reoperation during the same hospital stay. To determine the potential predictors of early reoperation we used univariate and multivariate logistic regression analyses.

Results: A total of 22 (6.51%) patients underwent unplanned reoperation. Those patients significantly more often were diagnosed with high grade glioma (81.82% vs. 55.70%; $p = 0.02$). They had lower Red Blood Cells count (4.16 ± 0.82 vs. $4.60 \pm 0.56\ 10^3/\mu l$; $p < 0.01$) and haemoglobin (12.58 ± 2.46 vs. 13.7 ± 1.72 g/dl; $p < 0.01$) and lower haematocrit (36.93 ± 6.84 vs. $39.94 \pm 4.66\%$; $p < 0.01$) preceding surgery. Surgeries of reoperated patients more often were performed during "on call" hours (17.65% vs. 4.49%; $p = 0.02$). After adjustment for possible confounders frontal craniotomy (OR: 2.961; 95% CI: 1.042–8.406; $p = 0.04$)and "on call" hours of surgery (OR: 2.961; 1.042–8.406; $p = 0.04$) remained independently associated with higher risk of reoperation.

Conclusions: Frontal craniotomy and surgery during "on call" hours are independently associated with higher risk of reoperation in supratentorial brain tumors.

1. Introduction

Unplanned reoperations constitute a significant part of complications in all of surgical specialties [1–4]. They are considered as important quality indicator and can be associated with significant economic burden [5]. In terms of neurosurgery, among all possible causes of operation brain tumors were proved to be at highest risk of unplanned reoperation both in children and adults [6–8]. Postoperative complications were shown to be associated with higher mortality [9,10] and postoperative haemorrhage established as most frequent cause of death [11]. Unplanned reoperation is also linked with prolonged hospitalization [9]. Reoperation rate among patients with brain tumors varies between 2 and 11% and most commonly indicated risk factors are clotting disorders, older age and infratentorial location [9,10,12]. However, there are still many inaccuracies in terms of other predictors especially that, due to our knowledge, there are limited studies analysing only intrinsic supratentorial tumors. Therefore, we decided to find possible predictors of complications leading to early unplanned reoperations among patients with supratentorial brain tumors. We also aimed at establishing rate of early unplanned reoperations for those patients.

2. Methods and materials

We retrospectively analysed 328 patients who underwent craniotomy due to supratentorial brain tumor operated in department of neurosurgery between January of 2015 and December of 2016. From their medical record we obtained detailed medical history which included chronic diseases and current medications. We also obtained blood test results taken within 24 h before surgery together with details concerning operation such as its date, duration, cause, type and side of craniotomy and whether doctor who performed surgery and their assistant were specialist in neurosurgery or neurosurgeon in training. Additionally, we obtained details about tumors such as its location, histological type and whether complete removal was achieved. Early unplanned reoperation was defined as reoperation that occurred during the same hospitalization. Study protocol was approved by local bioethical committee.

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Table 1
Detailed characteristics of patients that underwent reoperation and control group.

	Reoperation (n = 22)	No reoperation (n = 306)	p-value
Age [years] ± SD	60.18 ± 11.89	58.51 ± 13.88	0.58
Female gender [%]	50.00 (11)	48.42 (153)	0.89
Medical history			
Hypertension [%]	36.36 (8)	33.54 (106)	0.79
Diabetes mellitus [%]	9.09 (2)	15.19 (48)	0.44
Cigarette smoking [%]	18.18 (4)	19.62 (62)	0.87
Alcohol abuse [%]	4.55 (1)	9.18 (29)	0.46
Ischemic heart disease [%]	9.09 (2)	2.85 (9)	0.11
History of heart attack [%]	0 (0)	2.22 (7)	0.48
History of ischemic stroke [%]	0 (0)	4.11 (13)	0.33
Atrial fibrillation [%]	0 (0)	1.58 (5)	0.55
Lungs diseases [%]	0 (0)	0.95 (3)	0.65
Hyperthyroidism [%]	0 (0)	0.95 (3)	0.65
Hypothyroidism [%]	0 (0)	2.22 (7)	0.48
Hypercholesterolemia [%]	9.09 (2)	1.90 (6)	0.03
Current medications			
Acetylsalicylic acid [%]	0 (0)	3.48 (11)	0.37
Beta-blockers [%]	4.55 (1)	9.49 (30)	0.44
Angiotensin-converting-enzyme inhibitors [%]	18.18 (4)	12.97 (41)	0.49
AT_2-blockers [%]	0 (0)	0.63 (2)	0.71
Calcium channel blockers [%]	0 (0)	6.33 (20)	0.22
Diuretics [%]	9.09 (2)	13.92 (44)	0.52
Steroids [%]	9.09 (2)	15.19 (48)	0.44
Antidiabetic therapy [%]	0 (0)	5.06 (16)	0.28
Insulin [%]	0 (0)	2.22 (7)	0.48
Heparin [%]	0 (0)	4.75 (15)	0.30
Anticoagulants [%]	0 (0)	2.85 (9)	0.42
Nitrates [%]	0 (0)	0.32 (1)	0.79
Statins [%]	0 (0)	1.27 (4)	0.60
Blood test results preceding surgery			
Red Blood Cells count [10^3/μl] ± SD	4.16 ± 0.82	4.6 ± 0.56	< 0.01
White Blood Cells count [10^3/μl] ± SD	10.00 ± 6.48	10.85 ± 5.07	0.46
Platelets count [10^3/μl] ± SD	219.64 ± 62.24	243.65 ± 74	0.14
Haemoglobin [g/dl]	12.58 ± 2.46	13.7 ± 1.72	< 0.01
Activated Partial Prothrombin Time [s] ± SD	27.52 ± 3.4	26.74 ± 3.91	0.39
International Normalized Ratio ± SD	1.02 ± 0.08	1 ± 0.08	0.25
Creatinine [μmol/l] ± SD	64.48 ± 24.52	71.71 ± 16.85	0.07
Glucose [mmol/l] ± SD	6.98 ± 2.41	6.2 ± 2.05	0.10
Mean Corpuscular Volume [μm^3] ± SD	89.11 ± 3.46	87.08 ± 4.71	0.05
Mean Corpuscular Haemoglobin [pg] ± SD	30.3 ± 1.48	29.85 ± 1.83	0.26
Mean Corpuscular Haemoglobin Concentration [g/dl] ± SD	34.02 ± 1.05	34.27 ± 1.12	0.30
Urea [mmol/l] ± SD	6.69 ± 2.74	6.92 ± 2.94	0.73
Sodium [mmol/l] ± SD	139.82 ± 4.49	139.12 ± 3.61	0.39
Potassium [mmol/l] ± SD	4.16 ± 0.5	4.35 ± 0.43	0.06
Prothrombin Time [s] ± SD	11.74 ± 0.95	11.55 ± 0.82	0.36
Haematocrit [%] ± SD	36.93 ± 6.84	39.94 ± 4.66	< 0.01

2.1. Statistical analysis

To perform statistical analysis we used $\chi 2$ test for proportional values and *t*-Student test and Mann-Whitney *U* test as appropriate for continuous variables. To determine the potential predictors of re-operation after supratentorial brain tumor removal we used univariate and multivariate logistic regression analysis. P-values < 0.05 were considered to be statistically significant. Threshold of p-value < 0.1 was used to qualify date to multivariate logistic regression analysis. Forward logistic regression analysis was followed by backwards logistic regression analysis. To perform all statistical analysis we used STATISTICA v. 10 for Windows (Statsoft, Poland).

3. Results

3.1. Study group characteristics

Our study group consisted of 328 patients and 164 of them (46.19%) of them were females. Mean age of study group was 58.61 ± 13.73 years. Details concerning demographic data and past medical history and current medications are presented in Table 1. The most common histological type of tumor was high grade glioma (57.39%), then metastatic tumor (26.33%) and low grade glioma (16.27%). Thirty-nine (11.54%) of tumors were recurrent. The most common tumor location was frontal lobe (41.48%), then temporal lobe (39.77%), occipital lobe (11.36%), intraventricular location (3.41%), insula (1.70%), parietal lobe (1.14%) and pineal gland (1.14%). One hundred twenty-five (36.98%) of tumors were in cortical location (Table 2).

3.2. Unplanned reoperations

A total of 22 (6.51%) patients underwent unplanned reoperation. Those patients significantly more often had hypercholesterolemia (9.09% vs. 1.90%; p = 0.03) and were diagnosed with high grade glioma (81.82% vs. 55.70%; p = 0.02). In preoperative blood test results they had lower Red Blood Cells (RBC) count (4.16 ± 0.82 vs. 4.60 ± 0.56 10^3/μl; p < 0.01) and haemoglobin (12.58 ± 2.46 vs. 13.7 ± 1.72 g/dl; p < 0.01), higher Mean Corpuscular Volume (89.11 ± 3.46 vs. 87.08 ± 4.71 μm^3; p = 0.05) and lower

Table 2
Details concerning type of surgery and treated tumor characteristic.

	Reoperation (n = 22)	No reoperation (n = 306)	p-value
Surgery during weekend [%]	27.27 (6)	16.14 (51)	0.18
"On call" hours of surgery [%]	17.65 (3)	4.49 (12)	0.02
Surgery duration [min] ± SD	115.24 ± 67.49	138.58 ± 66.23	0.16
Bone flap removal [%]	36.36 (8)	20.57 (65)	0.08
Operating specialist	90.91 (20)	84.81 (268)	0.44
Asysting specialist	36.36 (8)	40.51 (128)	0.70
Lineal incision [%]	4.55 (1)	4.43 (14)	0.98
Craniotomy type			
Pterional [%]	0 (0)	1.58 (5)	0.55
Frontal [%]	50.00 (11)	31.33 (99)	0.07
Temporal [%]	18.18 (4)	7.91 (25)	0.10
Parietal [%]	4.55 (1)	17.09 (54)	0.12
Parieto-occipital [%]	9.09 (2)	9.81 (31)	0.91
Fronto-parietal [%]	0 (0)	9.18 (29)	0.14
Fronto-temporo-parietal [%]	9.09 (2)	12.97 (41)	0.60
Suboccipital [%]	0 (0)	4.75 (15)	0.30
Right side [%]	63.64 (14)	56.65 (179)	0.52
Left side [%]	54.55 (12)	55.70 (176)	0.92
Tumor location			
Frontal lobe [%]	13.64 (3)	22.15 (70)	0.35
Temporal lobe [%]	31.82 (7)	19.94 (63)	0.18
Parietal lobe [%]	0 (0)	0.63 (2)	0.71
Occipital lobe [%]	4.55 (1)	6.01 (19)	0.78
Insula [%]	0 (0)	0.95 (3)	0.65
Intraventricular [%]	0 (0)	1.90 (6)	0.51
Pineal gland [%]	0 (0)	0.63 (2)	0.71
Cortical [%]	22.73 (5)	37.97 (120)	0.15
Subcortical [%]	77.27 (17)	62.03 (196)	0.15
Tumor characteristics			
Subtotal resection [%]	0 (0)	5.70 (18)	0.25
Recurrent tumor [%]	22.73 (5)	10.76 (34)	0.09
High Grade glioma [%]	81.82 (18)	55.70 (176)	0.02
Low Grade glioma [%]	4.55 (1)	17.09 (54)	0.12
Metastatic tumor [%]	13.64 (3)	27.22 (86)	0.16

haematocrit (36.93 ± 6.84 vs. 39.94 ± 4.66%; $p < 0.01$). Surgeries of reoperated patients significantly more often were performed during "on call" hours (17.65% vs. 4.49%; $p = 0.02$). There was no significant difference in terms of tumor location. After adjustment for possible confounders frontal craniotomy (OR: 2.961; 95% CI: 1.042–8.406; $p = 0.04$ and "on call" hours of surgery (OR: 4.843; 95% CI: 1.101–21.286; $p = 0.04$) remained independently associated with higher risk of early reoperation in patients with supratentorial brain tumor.

3.3. Causes of unplanned reoperations

The most common cause of unplanned reoperations was cerebrospinal fluid leak (50%), then postoperative haemorrhage (27.27%), wound infection (13.64%) and brain edema (9.09%). The distribution of cause of reoperation according to the histopathological type of tumor is shown in Fig. 1.

4. Discussion

In this single center retrospective study we established frequency and possible predictors of early unplanned reoperations in supratentorial tumors.

In our study we established complication rate at about 6.5%. Lower rates were established by Dasenbrock et al. (3%) [9] and McLaughlin et al. (2%) [8]. Lonjaret et al. in their study found that about 11% of patients underwent reoperation [13] and Kageji et al. and Lassen et al. established rate of reoperation due to postoperative haemorrhage at about 2% [10,12]. In terms of pediatric neurosurgery Lassen et al. found that 0.4% of patients were reoperated due to postoperative haemorrhage and about 7% due to cerebrospinal fluid (CSF) leak [14].

An interesting finding in our study was independent association between surgeries performed during "on call" hours and higher risk of reoperation. Emergency brain tumor surgeries have also been determined as predictor of reoperation in Dasebrock et al. study [9]. Similar results were also observed by Nittiby et al. and Rolston et al. in terms of all neurosurgical procedures [15,16] and by Desai et al. in terms of pediatric neurosurgery [17]. In addition, emergency surgeries can be a risk factor of postoperative complications in general surgery [18] and cardiac surgery [1]. An explanation of those association can be the fact that patients operated after-hours are usually in worse general condition. Patients that are qualified for emergency tumor surgery usually present with increased intracranial pressure (ICP) or intracranial haemorrhage, which could affect postoperative complications. Also, night-time surgery can be more demanding for neurosurgeon. However, in other surgical specialties, surgeries performed during night were not associated with higher risk of poor treatment outcome [19].

Another finding of our study is significantly lower RBC count and haemoglobin in reoperated patients, as well as lower haematocrit and higher MCV. Those results indicate presence of anemia among reoperated patients prior to the initial surgery. Many researchers showed impact of preoperative anemia on mortality and postoperative complications in other surgical specialties [2,6,9,17,18,20–24]. In terms of neurosurgery, preoperative anemia was associated with higher mortality and risk of complications among patients who underwent elective cranial procedures [25,26]. Alan et al. in their study found that for patients with brain tumor anemia is a risk factor of prolonged hospital stay [27]. It was also linked with higher risk of infection after spinal surgery [28]. To explain those correlation other researchers suggested that anemia could indicate an underlying disease process [25,27]. It was also shown that it can cause changes in oxygen extraction ratio and regional blood flow in the brain [27,29]. Additionally, in terms of haematocrit, Lassen et al. found that patients with brain tumor who had lower haematocrit were at higher risk of postoperative morbidity [12].

Our study also showed that patients with high grade glioma are at higher risk of early reoperation, particularly due to a haemorrhage. Although other researchers have examined association between histological type of tumor and risk of reoperation, none of them found such correlation [9–13]. Fact that high grade gliomas growth is associated with increased angiogenesis [22] could explain such correlation.

We also found that frontal craniotomy was independently associated with higher risk of early reoperation. That correlation was also showed in our previous study, concerning all neurosurgical procedures [7], however it was not confirmed by any other researcher [9–13]. As we suggested in previous study, that association can be explained by the fact that during frontal craniotomy frontal sinuses might be opened, which could increase risk of postoperative infection [30].

Another finding of our study was higher risk of emergency reoperation in patient with hypercholesterolemia. None of other researchers found similar association [9–13]. We interpret this finding as a coincidence.

Our study was limited by fact that obtained data come from single neurosurgical facility experience. Further research should be performed as multi-centre study. Despite those limitation, we were able to analyse full range of possible complications requiring reoperation after supratentorial, intrinsic brain tumor surgeries during two years time period.

5. Conclusions

Patients with lower RBC count and haemoglobin, as well as with higher MCV and lower haematocrit are at higher risk of early reoperation after brain tumor surgery. Higher risk of emergency reoperation is also associated with surgery of high grade glioma. Frontal craniotomy and surgery during "on call" hours are independently associated with higher risk of complications requiring reoperation after

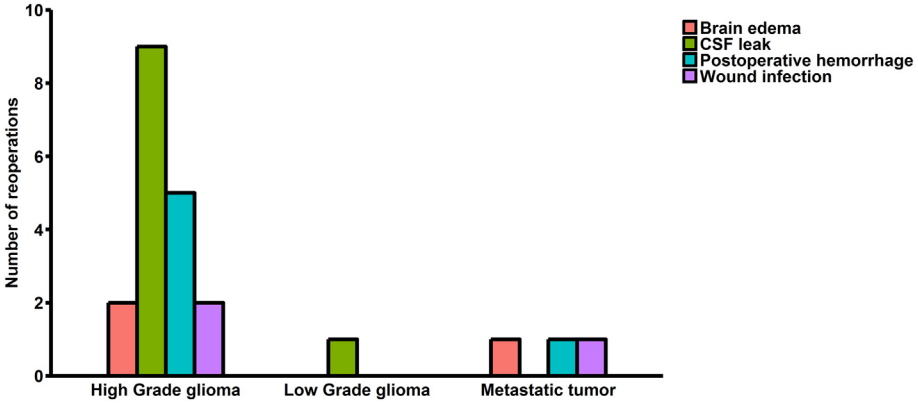

Fig. 1. General distribution of complication requiring reoperation.

supratentorial brain tumor surgery.

Compliance with ethical standards

Conflict of interest

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants included in the study.

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